

THE USE OF THE BONE GRAFT IN SURGERY

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THE present communication is more or less a résumé of the great advance in surgery through the application of bone-grafting. Many men have worked on this for years, in defects of the skull, defects of the long bone, and various deformities; but it is really only within the last two or three years that a thorough appreciation of what bone-grafting means has been recognized in surgery. It is a number of years since the transfer of a whole bone was used. You will all remember the historical case of Huntington, in which he transplanted the fibula to replace a defect in the tibia, and how the fibula developed, after some years, to the calibre of the original tibia.

The use of the bone graft, of course, is nothing new in surgery. Ollier, many years ago, used a bone flap with a pedicle, and a certain amount of success was the result. Several other men have also attempted it; among them Witzel replaced part of the clavicle with a graft from the spine of the scapula. Bittner transplanted a large graft from the tibia and turned it down to fill the gap of the resected portion. McEwan, of Glasgow, certainly deserves very great credit for his persistent belief in the future of such repair surgery, and it is very interesting to see that some of his original experiments have almost a practical application to-day. Digressing from my subject, mention must be made of the transplanting of the whole joint apparatus, and the remarkable attempts of Buchmann and Lexer in this direction.

My own first impression of free bone transplantation was in the summer of 1905, when on a short visit to Berlin I visited the Israel Clinic. Israel, that morning, was doing a third stage of a plastic operation on the nose for a complete defect, as a sequel of lupus. In this case, Israel had transplanted from the tibia three bone-plates; these he placed subcutaneously in the arm in a suitable position for a flap transplantation to the nose. Unfortunately,

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I do not remember how long he left the graft in the arm before his first flap operation. However, the three bone-plates were not absorbed, and at the time I saw the operation they remained as a firm skeleton support for the new nose. The flap had been transplanted in the usual way by preserving the skin pedicle in the arm until the suture line had taken.

For a time there was no particular advance until a rib was used as an autogenous graft. Later Albee of New York devised his operation for Pott's disease in which he provided a free and substantial graft taken from the tibia and inserted in the spinous processes of the vertebræ. The remarkable results attending this bone-grafting directed the attention of the surgical world to the variety of conditions in which it might be applied. Its application also in the case of delayed union of the long bones, or non-union, was quickly appreciated. As to the fate of the graft we must again refer to the three chief theories of regeneration of bone; but this surgical work has rather upset even these. Briefly, to mention them, they are as follows: (1) "The bone in the graft always dies, is absorbed and reformed from periosteum, which alone remains living in transplants." (Axhausen). (2) "The bone in a graft is reproduced from the proliferation of osteoblasts, derived from osteoblasts within the bone of the graft itself, and its regeneration takes place independently of the periosteum whose only function is that of a limiting membrane which prevents the spread of the osteoblasts into the surrounding tissues." (McEwan). (3) The "graft is not osteogenetic, but simply osteoconductive. Provided it be in contact at one or both extremities with other living bone, the graft acts simply as a scaffolding for the growth of the capillaries with their osteogenetic cells as they advance from the living contact extremities into the graft. The periosteum takes no part in the reproduction of new bone." (Murphy).

Axhausen's theory is now disproved, as also McEwan's of the physiology of the graft. Murphy's has most weight, though I will take up this later.

Since this bone-grafting, however, we find by carefully studying the *x*-rays of cases that in practically all the cases, the graft persists as a true bone splint. As far as we can make out, there is no diminution in the size and practically none in the density of the bone itself. I was much impressed some months ago by a paper of Geddes, of Dublin, on the regeneration of bone, in which he called attention to the fact that bone was regenerated by osteogenetic cells from all parts of the bone. It appeared as though the

greatest amount of regeneration took place in the neighbourhood of the periosteum, sub-periostially, and in the medulla; but, in addition to this, there were very numerous cells of the same character migrating throughout the Haversian systems. Gallie, of Toronto, has made a number of observations also on this subject, and in all his experiments found the graft at first without any circulation and with empty lacunæ—really dead, and in succeeding experiments showed the vascularization of the graft. MacWilliams, of New York, has called attention to the fact that the periosteum is a very important factor. This he did by imbedding portions of ribs in the abdominal wall. The cases which had periosteum were well preserved and living; those, however, which did not have periosteum were absorbed. This corresponded entirely with the plastic case which I cited above from the Israel Clinic. He also emphasizes that good circulation is a very important factor. This is, of course, only common sense, when we consider what repair of bone means. I must say I cannot yet give great weight to the necessity of the periosteum.

Up to the present time the function of the bone graft has been chiefly that of a long splint, used chiefly in defects of the long bones. Now we find that it has a certain application in repair of the patella, in fixation of the sacro-iliac joint, and from the example which I quoted above, seen in 1905, of broader thin plates of bone being used in plastic work, surely there must be some result in the application of the same for defects of the skull.

There are a number of methods for the selection of the graft. It may be taken from the tibia, rib, upper third of the ulna, clavicle or crest of the ilium. The rib and tibia are the favourites, the former for its abundance of vascular cancellous tissue, and the latter for the size of graft available. There are also a number of methods of transplantation, the chief of these being the transfer of free, non-pedunculated, large fragments, with or without periosteum covering at least one side. This is far the most generally employed to-day. Yet it is but just to mention others, some at present discarded: (1) The use of small bone chips with periosteum; (2) The decalcified bone chips of Senn; (3) The use of pedunculated bone flaps; (4) Graft combined with arthroplasty; (5) The shaft of the fibula (Huntingdon); and (6) The transplantation of joints (Buchmann and Lexer).

The indications for the use of bone grafts, according to Murphy, are as follows: (1) To correct deformities resulting from defects of development, as aplastic extremal bones—radius, ulna, humerus,

tibia, fibula and femur; saddle nose aplastic mandible, etc.; (2) To produce union in un-united fractures; (3) To replace bone removed by destructive infections; (4) To restore or supplant fragments dislodged or destroyed by fractures; (5) To replace bone removed for certain non-malignant or encapsulated malignant neoplasms; (6) To immobilize joints, as in Pott's disease (Albee) or infantile paralysis.

The ones which we are most interested in are those in which a free graft with or without its periosteum has been transferred. My own experience has been entirely with a graft taken from the tibia, varying in length from four to ten inches, and in width from three-eighths to three-quarters inch. Other operators have selected a rib; both are selected on account of the ease of access and the excellence of the bone graft afforded. In all cases which have come under my service, I have transferred the graft with the periosteum attached. The graft has been carried right through to the medullary cavity of the bone, a minimum of trauma is inflicted, and all the elements of repair are preserved as intact as possible, as suggested by Geddes, of Dublin. To remove the graft the means is certainly simple—a chisel can be readily used. This means I followed in my first five cases, but since then I have used a rotary saw on account of its rapidity of work, accuracy of cutting, and the avoiding of the chance of the bone splitting in a wrong direction. The bone graft has only been removed from its host after the site of grafting has been prepared; then it is quickly transferred into the bed prepared, the periosteum sutured, and the accuracy of the fitting of the graft carefully insured. The number of instruments really is a very simple one but it is wise to add a simple block of wood four by four by two inches, and a saw. By this means you can readily chisel or saw off any excess of the graft. I recommend this after my own experience, since in one case, as I was placing a graft in position, it slipped from the forceps on to the floor. In that case I was using a very thin graft, fortunately, and without any injury to the patient I was enabled to take a second one. In all cases I think it is wise, in addition to suturing the periosteum, also to suture the layer of aponeurosis before closing the skin. One other site on which great stress is usually thrown both in un-united fractures and also in the Albee operation on the spine, is the end of the graft, and this must be carefully secured in its bed. Nothing is more humiliating than after having done a very careful operation, to find that the result of the operation is very much impaired by the slipping out of one end of the graft.

My own experience in bone-grafting has been entirely in cases in which Albee's operation was performed, and in some cases of non-union. In all of these I removed the graft from the smooth surface of the tibia internal to the crest. The reason I chose this site was its simplicity, the fact that in removing the graft I preserved the dense crest of the tibia and, thirdly, that the operator did not invade the muscle on the outer side of the crest. These grafts were then inserted in a furrow, either in the back or else in the non-united bone of the opposite side. The results were very gratifying. In the first place the bone graft persisted; there was practically very little shock to the patient and the functional results were excellent. This has been the experience of many other men who followed exactly the same technique. The reason for favouring this technique was the fact that healthy bone was chosen; there was no trauma in removing the graft or inserting it in its new locality. All the constituent elements from periosteum to medulla were preserved absolutely intact. However, in the surgical clinic in the Royal Victoria Hospital all three of the standard methods have been used with excellent results in each. These methods are: first, the transplant of the bone into a furrow arranged for it in a new locality, as first described by Albee; secondly, the method, described by Buchanan, of Pittsburg, in delayed-union fractures, of moving the graft from the same bone down to make a solid bridge over the fractured area; and thirdly, the methods strongly advocated by Murphy, of Chicago, of enlarging the medulla of each fragment, taking a bone graft from the sound tibia, and inserting it as a peg to bridge between the two fragments. From described cases from various clinics, it appears to me that each method has a distinct place; and the advance in this type of surgery is astonishing in the last three years, filling in the gap of treatment in delayed union from a thorough surgical standpoint. What has appealed particularly to me is the simplicity, and the preservation of all constituent cells where the repair has to take place. The last method does cause a great deal of trauma in the medulla; but the more solid splinting brought about by this method may give the other parts of the bone a better chance for union, to compensate for this trauma. In any case the results are extremely gratifying.

In all my cases the graft has been taken from the patient. The repair of the patient must be at its maximum, and the technique of preparation of patient and operator must be absolutely scrupulous. It must be remembered that any carelessness in this last may lead to infection, grave or slight, of one or both tibiæ, and that serious disability may result.

As to the fate of the graft, MacWilliams, in a recent article in the *Annals of Surgery*, gave a very careful review of his experiences and also experimental work. He emphasized very strongly his opinion that the periosteum was an important factor, not so much the fibrous envelope itself, as the subjacent cells. He held very strongly, as does also Albee, that the bone united in its new position, with its host, even as a fracture does. I was strongly inclined in this belief myself, especially as in one case of spine-splinting the upper end of the graft slipped out of the spinous process above, and the gap was first closed by a bridge of callus, and later by true bone. However, the careful work of Gallie, which he reported last month at the meeting of the Orthopædic Association, must be recognized. In his series of experiments he found in almost every case, that for some time the lacune of the bone and Haversian systems were destitute of circulation, and that this circulation became gradually reestablished. The emphasis which MacWilliams has laid on the importance of circulation is an important factor. He practically repeated one of McEwan's original experiments of placing bone chips in a suitable environment, and found that a shaft of new bone was the result.

In conclusion I would say that autogenous bone-grafting is a distinct advance, but the operation must be done with scrupulous care; that the graft must be regarded as a bone splint until revascularized from its host, and finally the extent of graft must be judged by the extent of this revascularization.

Discussion:

MR. RUTHERFORD MORISON said that there were still many points requiring investigation before all doubts were removed concerning the use of bone grafts. Two things appeared to be certain: (1) That the graft should be taken from the individual operated upon. The probable explanation of Lexer's failures appeared to depend upon his inability to comply with this requirement. (2) The need for most strict surgical precautions, which had been emphasized by every speaker. Where should the graft be taken from? If it was only, as Murphy said, a framework for new bone, to be laid down upon, the question was not of great practical importance. This was not Mr. Morrison's belief. He thought that the graft was the most important contribution to the new bone formed. If so, it might matter which bone was used—his experience, recorded in Vol. I of the *British Journal of Surgery*

recently issued, suggested that it did—and, for example, a good tibia might not result from a rib transplant. It seemed to him that a large bone would not grow from a small one for the same reason as the ovum of a mouse could not be expected to develop an elephant. The vascular supply of the graft appeared to him to be important, and when employing compact bone for the purpose, he had drilled holes at intervals to allow new vessels to get in there.

DR. ELDER said he used a rib because he got bone-marrow to bone-marrow, and so secured, he thought, much more rapid union than when cancellous tissue was used. He agreed with Mr. Morison as to preference for autogenous grafts, but no graft must be too long. If it is, the graft will not remain long enough to serve as a conductor for new bone. As regards technique, he laid great stress upon perfect hæmostasis, attained, if possible, by forcipressure ligatures; buried sutures were objectionable and should be avoided when possible.

DR. CLARENCE L. STARR: "If one can feel that evidence produced in experimental work in animals can be used to show what will happen in the human, then my associate, Dr. Gallie, has shown definitely that it does not matter whether the graft is autogenous or heterogenous, as all grafts grow equally well. The graft from the human can be planted into animals, from one animal to another, and even boiled grafts may be used. The graft dies, is revascularized from the tissues into which it is planted, and osteoblasts follow, the bone cells being laid down from the edge of the graft. As the compact tissue is invaded it becomes cancellous and gradually disappears, new bone being laid down as the old disappears. These experiments certainly open up a new field of possibility in bone work."

The Dietetic and Hygienic Gazette, which has just completed the thirtieth year of its existence, has been purchased by the Critic and Guide Company, with which it has been consolidated. Beginning last month the combined journals will be under the editorship of Dr. William J. Robinson, and will be published at 12 Mount Morris Park West, New York City.